

A Visual Guide to Help Producers Manage Jointed Goatgrass

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Jointed goatgrass is a prominent weed infesting winter wheat in the western United States. Individual control tactics often are ineffective and inconsistent, but management systems comprised of several tactics designed to disrupt population dynamics of jointed goatgrass can reduce infestation levels in winter wheat. Tactics are planned to favor decline of seedbank density, reduce seedling emergence in winter wheat, and minimize seed production of plants established in winter wheat. We describe a visual guide that will help producers plan management systems for jointed goatgrass with a diversity of cultural tactics. The guide organizes cultural tactics by decision times of producers during the winter wheat production cycle. Scientists are effectively managing jointed goatgrass in a diversity of production systems by integrating cultural tactics across decision times.

Nomenclature: Jointed goatgrass, *Aegilops cylindrica* Host. AEGCY; winter wheat, *Triticum aestivum* L.

Key words: Decision times, integrated management, systems, AEGCY.

Scientists are changing their approach to weed management by including cultural tactics related to weed population management along with control tactics such as herbicides and tillage (Mortensen et al. 2000). A goal with this approach is to increase number of mortality events during a weed life cycle to disrupt population growth.

For example, the number of viable seeds in soil can be reduced by rotations comprised of crops with different life cycles (Froud-Williams 1988). Different planting and harvest dates among these crops provide opportunities for producers to prevent plant establishment and seed production by weeds, thus reducing seed density in soil. Fewer seeds in the seedbank usually leads to fewer seedlings in following crops (Roberts 1981; Sagar and Mortimer 1976).

Seedbank density can also be reduced by maintaining weed seeds on the soil surface over winter; number of viable seeds declines because of exposure to environmental extremes and predation (Mortimer 1984). For example, winter survival of wild oat (*Avena fatua* L.) seeds on the soil surface was less than 10%, whereas over 50% of seeds buried 2 to 5 cm in soil were viable after 5 months (Sagar and Mortimer 1976). Similar trends have been found with other weed species in the United States (Egley and Williams 1990), New Zealand (Popay et al. 1994), and Canada (Thomas et al. 1986), where loss of seed viability was highest when seeds remained on the soil surface.

Tilling shallowly to bury weed seed also enhances seedbank decline by stimulating weed germination (Froud-Williams 1988). Egley and Williams (1990) found that the greatest decline in seedbank density occurs when weed seeds remain on the soil surface over winter, followed by shallow tillage in early spring to stimulate germination during the growing season.

A second approach to suppressing weed population growth is increasing crop competitiveness (Mortimer 1984). For example, O'Donovan et al. (1997) found that banding N fertilizer with barley (*Hordeum vulgare* L.) seed at planting reduced green foxtail [*Setaria viridis* (L.) Beauv] seedling density as well as the subsequent seedbank density more than

90% compared with N applied broadcast. Access to banded N increased early-season growth of barley, thus improving its competitiveness with green foxtail. Other cultural strategies that increase crop competitiveness with weeds include taller cultivars, higher seeding rates, and narrower row spacing (Carlson and Hill 1985; Challaiah et al. 1986).

Jointed goatgrass is a prominent weed in winter wheat in the western United States (Donald and Ogg 1991). When scientists first started research with jointed goatgrass in the 1980s, herbicides were not available to control jointed goatgrass in winter wheat. Therefore, scientists focused research on developing cultural tactics to suppress jointed goatgrass.

Later, development of imidazolinone-resistant cultivars of winter wheat allowed the use of imazamox to control jointed goatgrass in winter wheat (Newhouse et al. 1992). However, efficacy of imazamox varied considerably. In a multilocation study in the Pacific Northwest, control levels with imazamox applied at 36 g/ha ranged from 61 to 97% (Ball et al. 1999), whereas control has been less than 40% in some years in the central Great Plains.¹ This range in efficacy has been attributed to environmental conditions such as drought stress at time of application. A new concern has also developed; pollen flow between imidazolinone-resistant winter wheat and jointed goatgrass may transfer resistance to jointed goatgrass and eliminate the efficacy of imazamox (Seefeldt et al. 1998; Zemetra et al. 1998).

Thus, scientists continued to emphasize research with cultural tactics. But individual tactics were only moderately effective. For example, Kappler et al. (2002) reported that increasing seeding rate of winter wheat suppressed growth of jointed goatgrass in only two sites of four. This variability was attributed to differences in environmental conditions and time of jointed goatgrass emergence among sites.

Control levels can be improved by combining several cultural tactics together. A cultural system of a tall cultivar planted at 50% higher seeding rate with N fertilizer banded by the seed reduced jointed goatgrass seed production 45 to 60% compared to conventional practices (Figure 1). In contrast, seed production was reduced only 5 to 10% when

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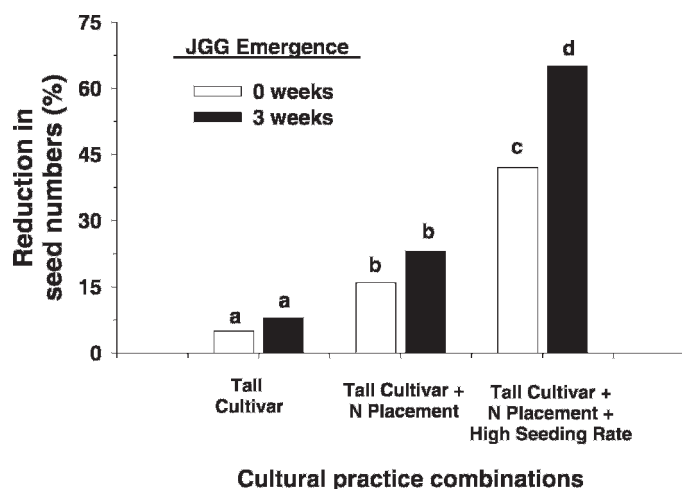


Figure 1. Enhanced suppression of jointed goatgrass seed production when cultural tactics are combined together. The emergence interval represents time of jointed goatgrass emergence in relation to emergence of winter wheat. Bars with an identical letter are not significantly different on the basis of Fisher's protected LSD (0.05). Means for the tall cultivar treatment did not differ from the conventional system (adapted from Anderson 1997). Abbreviation: JGG, jointed goatgrass.

one tactic was used. Yet, even with cultural systems, control was still variable. Yenish and Young (2004) reduced jointed goatgrass growth with a cultural system comprised of a tall winter wheat cultivar, increased seeding rate, and large seed size compared with conventional practices. However, jointed goatgrass biomass was reduced 46% by the cultural system in one year, but only 16% in the following year.

Therefore, scientists began a series of integrated systems projects comprised of cultural tactics targeted to disrupt population growth of jointed goatgrass (Anderson et al. 2004). A key lesson learned from these projects is that jointed goatgrass can be successfully managed if control tactics are imposed at several times during the life cycle of jointed goatgrass. The cultural tactics used in these successful management projects can be arranged by four decision times of producers during the winter wheat production cycle (Figure 2).

Cultural Tactics during the Interval Between Winter Wheat Crops. Jointed goatgrass seed density in soil can be reduced by including crops with different life cycles in rotation with winter wheat. Producers can easily control jointed goatgrass during the growing season of the alternative crop, thus preventing seed production and favoring the natural loss of live seeds in soil across time. With time, number of live jointed goatgrass seeds in soil declines because of germination, predation, or natural death; more than 80% of jointed goatgrass seeds remain 1 yr after seed shed, whereas less than 30% are still present after 2 yr (Figure 3). Also, tilling soil shallowly during fallow to place seeds in 1 to 3 cm of soil will stimulate seed germination, allowing producers to control these seedlings before planting winter wheat (Evans et al. 2001).

Another option to reduce seed density in soil is to burn winter wheat residue after harvest, which kills jointed

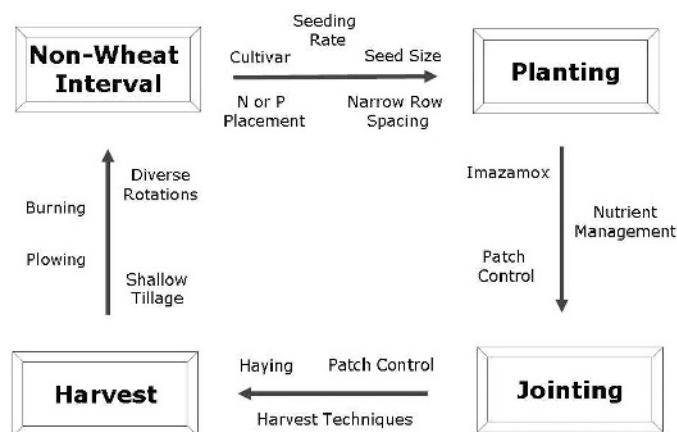


Figure 2. Possible cultural tactics at various decision times during the winter wheat production system.

goatgrass seeds near the soil surface (Young et al. 1990). Producers also can moldboard plow to bury seeds deeper than the capacity for seedlings to emerge. However, using these tactics can be detrimental to soil conservation and environment protection. Also, moldboard plowing is effective only if used once every 4 or 5 yr.

Cultural Tactics before Planting Winter Wheat. Delaying the planting time of winter wheat may provide an additional opportunity for producers to control jointed goatgrass seedlings before planting. This tactic is especially helpful if producers have tilled the soil shallowly during the fallow period. Effectiveness of this approach, however, is inconsistent (Wicks 1984) and yields are often decreased when winter wheat is planted outside its optimum planting date range (Cook and Veseth 1991).

Producers also can improve winter wheat competitiveness with jointed goatgrass. Higher seeding rates (Kappler et al. 2002) or taller cultivars (Ogg and Seefeldt 1999) result in a denser winter wheat canopy, thus minimizing light

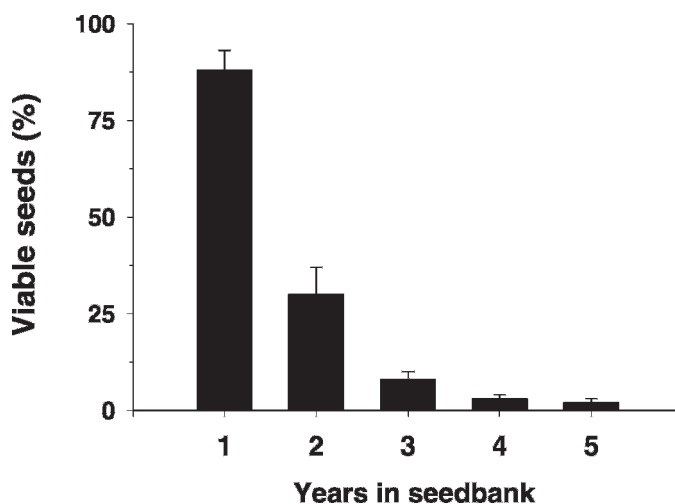


Figure 3. Number of jointed goatgrass seeds remaining in the soil seedbank across time in the Great Plains. Error bars indicate 1 standard deviation (adapted from Donald and Zimdahl 1987).

penetration to jointed goatgrass. A similar benefit occurs with placing nutrients near the crop seed (Mesbah and Miller 1999), planting larger size seeds (Yenish and Young 2004), or using narrow row spacing (Anderson 1997). As shown in Figure 1, crop competitiveness is enhanced by combining several cultural tactics together.

Cultural Tactics after Planting but before Winter Wheat Jointing. After establishment of winter wheat and jointed goatgrass, producers can control jointed goatgrass with imazamox if imidazolinone-resistant cultivars are grown (Ball et al. 1999). The efficacy of imazamox is improved by cultural tactics that strengthen winter wheat competitiveness.¹

If jointed goatgrass is present only in isolated patches, producers can minimize seed production by eliminating those patches with nonselective herbicides such as glyphosate or with tillage. If N fertilizer is applied after the crop emerges, applying it in a band between every other row will reduce jointed goatgrass access to N somewhat; broadcasting N fertilizer during the crop season is especially favorable for jointed goatgrass growth (Mesbah and Miller 1999).

Cultural Tactics before Harvesting. Producers will help long-term management if they prevent jointed goatgrass dispersal in the field at harvest. Woolcock and Cousens (2000), evaluating *Bromus* spp. and *Avena* spp. population growth in Australia, reported that dispersal during combine operations increased rate of spread by these species 16-fold compared to a system where seed dispersal at harvest was prevented. They found that a weed's rate of spread in a field was more dependent on dispersal than on demographic factors.

In production fields, jointed goatgrass is often aggregated in patches (Donald and Zimdahl 1987). Thus, harvesting infested patches in a field last will minimize jointed goatgrass dispersal by the combine. Also, eliminating infested patches by either haying or killing plants with nonselective herbicides before grain harvest will prevent seed production and dispersal.

Examples of Successful Management Systems

A trend noted with research across the western United States is that management systems were most effective in controlling jointed goatgrass if comprised of cultural tactics from at least three of the decision times (Figure 2). A diversity of cultural tactics used during several times of the life cycle of jointed goatgrass is more disruptive of population growth, in contrast with cultural tactics imposed only at one decision time.

Central Great Plains. In Nebraska, a system comprised of numerous control tactics reduced jointed goatgrass density 900-fold compared with the conventional winter wheat–fallow system used by producers (Wicks et al. 2003). The system included a summer annual crop, corn (*Zea mays* L.), in the rotation to reduce seed density in soil. A second cultural tactic was tilling 3 to 5 cm deep 5 months before planting winter wheat to stimulate germination and seedling emergence of jointed goatgrass; seedlings were controlled before

planting winter wheat. Also, winter wheat competitiveness with jointed goatgrass was improved by growing a tall cultivar, increasing the seeding rate 50% higher than normal, and placing N fertilizer by the seed row. This production system of multiple tactics almost eliminated jointed goatgrass after 6 yr; in contrast, 900 seedlings of jointed goatgrass/m² were present in winter wheat grown with conventional practices.

Pacific Northwest. Integrating tactics from several decision times together also is successful with managing jointed goatgrass in the Pacific Northwest (Young et al. 2006). One effective system included burning winter wheat residue after harvest and adding spring wheat to the winter wheat–fallow rotation to reduce seedbank density. In addition, the system included three cultural tactics, tall cultivar, large seed size, and higher seeding rate, to improve competitiveness of winter wheat. Also, timing of application and placement of N fertilizer was designed to favor winter wheat. This system reduced jointed goatgrass density 86% compared with the conventional system used by producers. In contrast, when management systems were comprised of tactics from only one or two decision times, jointed goatgrass density was reduced only 30 to 40%.

Southern Great Plains. Jointed goatgrass is prevalent in the continuous winter wheat rotation in south central Kansas and Oklahoma. With a diversity of cultural tactics, Stahlman¹ devised a management system that reduced jointed goatgrass density in this rotation. When the management system was initiated, the field was moldboard plowed once to bury jointed goatgrass seeds and reduce seedling emergence. Crop competitiveness was improved by increasing seeding rate 50% compared to the conventional seeding rate, using large-size wheat seed, and applying N starter fertilizer with the wheat seed. After planting winter wheat, imazamox was applied to control jointed goatgrass seedlings.

After 5 yr, jointed goatgrass density in early September was only 1 plant/m² with this system comprised of tactics from several decision times. In contrast, management systems that relied on tactics imposed only during one decision time, such as at planting time, had more than 30 jointed goatgrass plants/m².

A Visual Guide for Planning Management Systems

The arrangement of cultural tactics in Figure 2 provides a conceptual framework for producers to organize tactics into management systems. Producers can plan for a series of cultural tactics to disrupt population growth of jointed goatgrass during the winter wheat production cycle. Cultural tactics listed in the figure can be replaced by other tactics, but successful management of jointed goatgrass requires tactics from several decision times. Also, this guide will help producers manage other winter annual grasses such as feral rye (*Secale cereale* L.) or downy brome (*Bromus tectorum* L.) that infest winter wheat.

Producers can gain a further benefit from this approach, as these tactics will also disrupt population growth of weed communities. For example, in the central Great Plains, community density of both cool- and warm-season weeds

were reduced by a multitactic system such that weed management costs were reduced 50% compared with the conventional system used by producers (Anderson 2005). Derksen et al. (2002) reported a similar benefit in the Canadian prairies; integrating crop diversity, varying planting dates, and fertilizer placement with weed management enabled reduced-herbicide-input systems to manage weed communities as effectively as conventional herbicide systems. A similar approach in the Netherlands reduced herbicide input more than 30% compared to conventional practices used by producers, yet weed management was effective with both systems (Lewis et al. 1997).

Sources of Materials

¹ 2005 National Jointed Goatgrass Research Program Progress Reports. Copies available from Sandra Ristow, Agricultural Research Center, Washington State University, P.O. Box 646240, Pullman, WA 99164-6240.

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